# An Interim Summary Report for Firefighter Protective Ensemble (FFPE) Testing


**Prepared by**

## The Chemical Weapons Improved Response Program

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## Soldier and Biological Chemical Command Aberdeen Proving Ground, Maryland

## Disclaimer

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## Preface

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This report has been approved for public release.

# Table of Contents



## FIGURES



## TABLES

# An Interim Summary Report for Firefighter Protective Ensemble (FFPE) Testing

## 1. Test Objectives.

The primary objective of the firefighter protective clothing assessment (turnout gear testing) is to evaluate the degree of protection against chemical warfare agents provided by standard firefighter protective gear during a quick rescue. Testing was conducted with firefighters wearing self-contained breathing apparatus (SCBA) for eye and respiratory protection and bunker gear for skin protection. However, the SCBA was not evaluated during these tests since it is known to offer excellent respiratory and eye protection for chemical agents. The tests conducted evaluate skin protection provided by the turnout gear ensemble for chemical agent vapors. These tests are called Man-In-Simulant Tests (MIST).

## 2. Test Overview.

Man-In-Simulant Tests (MIST) vapor tests measure the actual absorption of agent vapor simulant (methyl salicylate, basically wintergreen oil) into human skin by using passive samplers located on 17 skin regions of the body. Methyl salicylate is a safe non-toxic ingredient that is commonly used in rubbing compounds such as Bengay®. The samplers are applied directly to the test subject's skin using a "peel and stick" adhesive on the back of the sampler. Figure 1 shows a passive sampler that has been applied to the neck area of a test volunteer. The samplers small plastic pouches are filled with TENAX® powder that adsorbs the simulant vapor (methyl salicylate) at approximately the same rate as human skin.

**Figure 1. Sampler Applied to Neck Region**

The test subjects dress in standard turnout gear with SCBA. They are then directed to enter a chamber filled with methyl salicylate vapor simulant while performing a series of simulated rescue activities for 30 minutes. Two of the activities are shown in the chamber below; the ladder climb in Figure 2 and the 160-pound dummy drag in Figure 3. After testing is completed, the samplers are removed from the test subjects and the TENAX® adsorbent is carefully removed from the plastic sample pouch and loaded into stainless steel sorbent tubes. The simulant vapor that has been captured by the TENAX® powder is then thermally desorbed and analyzed on a gas chromatograph to determine how much methyl salicylate was adsorbed on each sampler.

**Figure 2. Ladder Climb**

**Figure 3. Dummy Drag**

Initial MIST vapor tests were conducted at the U.S. Army Soldier and Biological Chemical Command (SBCCOM) at Aberdeen Proving Ground, MD. Follow-on verification MIST tests were conducted at the Royal Military College (RMC) in Kingston, Ontario, Canada. RMC served as an independent test facility to validate the vapor test results generated at SBCCOM. Additional testing was also conducted at SBCCOM to assess the improvement in protection that could be achieved by applying field expedient modifications to the bunker gear using materials available to virtually all firefighters. These "quick fix" tests included: duct taping the wrist, ankle, fly, neck, and waist closures. Duct taping was done in two ways: self-taping and more extensive two-man taping called buddy-taping. In addition, single and double plastic trash bags in a raincoat type configuration and a Tyvek F® suit worn underneath the turnout gear with the closures taped were also evaluated. Examples of various quick-fix test configurations are shown in Figures 4-7 below:

**Figure 4. Buddy–Taped**

**Figure 5. Self –Taped**

**Figure 6. Tyvek F (shows opening at neck)**

**Figure 7. Tyvek F (close up to show sealing with tape)**

## 3. Test Results.

The laboratory analysis of all passive samplers is used to determine the protection provided to the wearer in terms of a protection factor (PF). The ensemble's protection factor (PF) is defined as the average exterior dosage divided by the average dosage inside the suit (firefighter's measured skin dosage):

PF = Exterior Dosage/Dosage Inside Suit

In other words, PF indicates how well the bunker gear protects the firefighter's skin from chemical agent vapors as compared to the potential exposure without wearing the gear. For example, looking in Table 1, the average PF is 11 for a firefighter wearing standard turnout gear with no quick-fix applied. That means that the protection to the firefighter's skin from chemical agent vapor is 11 times better while wearing standard turnout gear as opposed to wearing no protection at all. Listed in Table 1 are the average PF's for standard turnout gear and 5 quick-fix's that were implemented during MIST testing.

**Table 1. Protection Factor (PF) Results**

| Suit Configuration | # Suits Tested | Average Overall PF | Standard Deviation |
|---|---|---|---|
| **FFPE (standard, no quick-fix)** | 16 | 11 | 2.7 |
| **Buddy-Taping** | 4 | 22 | 8.1 |
| **Self-Taping** | 4 | 17 | 5.8 |
| **Tyvec F Under FFPE** | 5 | 111 | 46.3 |
| **Single Trash Bag** | 4 | 18 | 3.4 |
| **Double Trash Bag** | 4 | 28 | 3.4 |

It is important to note that the test results presented in table 1 are only indicative of the performance of newly manufactured PBI structural gear.

## 4. Follow-on Turnout Gear Testing.

Because test results generated to date are limited to one type of structural gear, follow-on tests are planned to bridge the current FFPE test results to other common types of firefighter structural gear used across the nation. The basic goal is to perform MIST tests using a selection of bunker gear made of differing fabrics and suit configurations which are representative of the typical types of gear used throughout the country and determine if there are any significant differences in protection factors or stay times using these protective systems. These tests are scheduled to be conducted during April and May of 1999. Some of the types of gear that will be tested are: used PBI fabric, used and new Nomex fabric, and several other selected configurations. Upon completion of the additional testing, SBCCOM will perform a hazard analysis to estimate stay times for firefighters performing quick rescue operations. These determinations will be developed

using the MIST test results along with toxicological data of various chemical agents and the development of a number of credible threat scenarios. These efforts will be captured in a final comprehensive report entitled "Guidelines for Incident Commander's Use of Firefighter Protective Ensemble (FFPE) with Self Contained Breathing Apparatus (SCBA) for Rescue Operations During a Terrorist Chemical Agent Incident". It is anticipated that this publication will be available in late summer of 1999.

## 5. Conclusions.

Protection Factors in Table 1 demonstrate that improvements to the firefighter's protection against chemical agent vapors can be improved by sealing the closures with various quick-fixs such as duct taping, a protective suit underneath the gear, or plastic trash bags. The trash bag quick-fix was determined to be too time consuming to be implemented. Actual stay times for firefighter entry into a chemical agent vapor during a quick rescue scenario was beyond the scope of this interim report. The issue of safe stay times will be provided in the final comprehensive guidelines report planned to be published in late summer of 1999.